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MUTUAL INFLUENCE OF INDIVIDUALS WITH DIFFERENT LEARNING PERFORMANCE IN EXPLORATORY BEHAVIOR OF THE FISH BUENOS AIRES TETRA (*HEMIGRAMMUS CAUDOVITTATUS*, CHARACINIDAE)

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ABSTRACT. In order to clarify the question of whether the schooling fish individuals with different analytical abilities act independently or if their behavior is mutually correlated, a comparison was carried out of two strains of Buenos Aires tetra (*Hemigrammus caudovittatus*) differing in their learning performance. We used normally colored form (red fin tetra, RFT) with high learning performance and yellowish morph (lemon tetra, LT) and with low learning performance in three variants of experimental groups: 10 RFT (I), 10 LT (II), and 5 RFT + 5 LT (III). A group was placed into a large aquarium with a model of stationary trap net inside it, and the time from the fish entrance into the trap to the coming out of it was estimated. The group I rapidly found the way out of the trap while the group II practically did not come out of it. The rate of leaving the trap in the group III did not differ from that in the group I. Thus the behavior of school of fish explorating a new water area depends on the composition of individuals in the school. At great differences between the school members, the school behavior is determined by reactions of individuals perceiving new information most actively, but it is not an arithmetical mean over the entire group.

Key words: exploratory behavior; mutual influence; learning performance; fish school; Hemigrammus caudovittatus.

The intra-species differences in learning rate are well-known for fish (Leshcheva and Zhuikov 1989, Magurran 1986). Consequences of this variety can be essentially different for individually living and schooling species. In the latter there are mechanisms of information transmission within the group which allow unlearned individuals to react adequately to one or another situation. This has been particularly shown in experiments on schools which included individuals acquainted with the test situation (Leshcheva and Zhuikov 1989).

However it remains unclear: 1. How will individuals with different learning performance behave at simultaneous placing into a new environment? 2. What will be behavior of groups of fishes consisting of individuals that are similar or different in their learning performance? 3. Whether the resulting reaction of the group in the latter case will be «arithmetical mean» of possible individual reactions?

To answer these questions, we compared behavior of two strains of the fish *Hemigrammus caudovittatus* that differ in learning performance, but not in motor activity in open field, and are able to form a common school with typical schooling behavior.

Material and methods

Two aquarium strains of *H. caudovittatus* were used in experiments: the red fin tetra (normally colored) and the lemon tetra (an albino form with yellowish tint of the body coloration). These two morphs were chosen due to the fact that, as it has been shown in preliminary experiments (Zhuikov 1991), the red fin tetra differs from the lemon tetra in significantly higher learning performance. The mentioned peculiarity allowed to test fishes in experimental installation without preliminary determination of their learning performance and having adopted that the red fin tetra individuals are well-learning animals while the lemon tetra individuals are poor-learning ones.

Seventy-five fishes of each morph were used in experiments; each tested group consisted of 10 individuals. Three variants of experimental groups were studied: 1) 10 red fin tetra individuals;

2) 10 lemon tetra individuals; 3) mixed group of 5 red fin tetra and 5 lemon tetra individuals.

Animals of each morph were of the same generation, the fish age was 4 months, and the fish length was 15-30 mm. Fishes of different morphs were kept separately in 200 L aquariums.

As a test, experimental group of fish was released into aquarium 180×180 cm with a model of stationary net trap within it (Fig. 1). The experimental chamber was basically analogous to that used in experiments of Matuda (Matuda et al. 1986) in studies on schooling reactions of small fish. The difference was that, instead of impenetrable plastic walls of the net trap, we made them of white net with 3 mm mesh. Walls of the stationary net trap were 10 cm high which was equal to the water level in the aquarium.

The experiments were performed in the following order. Fishes were caught from aquarium and placed into a transporting container 10 cm^3 in volume. When the number of caught individuals reached a certain value, they were placed into an opaque plastic cylinder 10 cm in diameter situated in the open part of experimental device. Two minutes later, when the animals calmed, the cylinder was removed.

After release of fishes into the open zone (left «open field») of the device they usually formed 1-2 schools which entered trap during the period from several seconds to 2 minutes in homogeneous groups and from 1 to 14 minutes in mixed ones. Experimental time count began when all 10 individuals came into the trap. The number of individuals inside the trap was registered visually every 5 minutes, and the number of fishes in main divisions of the device was recorded simultaneously. The duration of experiment, 3 hours, was established in preliminary test. For this period, the red fin tetras had time to visit all the parts of experimental device.

Inasmuch as we were interested in the maximum time of stay of individuals in the trap, the results of each experiment were approximated by a logistic curve with two asymptotes: the upper — 10 (all the 10 individuals in the stationary net trap) and the lower — 0 (all the individuals outside the trap). Since the re-entrances of fishes were possible after they left the stationary net trap, to calculate the curve, we used data obtained from the beginning of experiment to the moment when a monotonous decrease in the number of individuals inside the trap was still observed. Further we calculated the time from the moment of the school entrance to the trap to the upper inflection point of logistic curve which characterized the duration of the fish stay inside the net trap. To determine the significance of differences in the fish containment inside the trap, a comparison of data obtained was performed with Mann-Whitney non-parametric criterion.

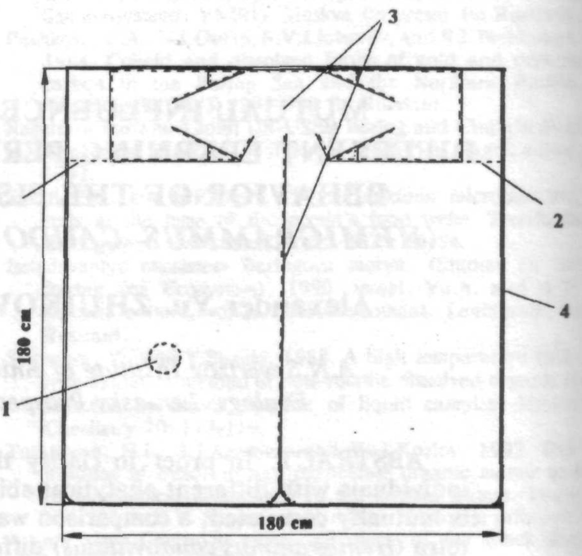

Fig. 1 Scheme of experimental installation
1 — place of fish release; 2 — fences; 3 — trap and leading wing; 4 — aquarium wall.

Results

The results of experiments show (see Table) that there are significant differences between the tetra groups tested in the duration of stay inside the stationary net trap. Groups of red fin tetra repeatedly visited all parts of the trap during the period of experiment. Then they left it for open zones of experimental installation and, after a time, again began to enter the net trap.

Behavior of the lemon tetra groups was similar to that of red fin tetra, however, they showed only a slight tendency to leave the trap during the experiment.

The results of experiments with mixed groups show greater variety in the duration of stay inside the trap than it was observed in the red fin tetra schools. Nevertheless, all mixed groups left the trap rather rapidly (Table).

As the statistic analysis has shown, the duration of stay inside the trap was different for fishes from the red fin and lemon tetra schools (Mann-Whitney U-test, p = 0.009). Mixed groups were also sharply different in this index from the lemon tetra groups (Mann-Whitney U-test, p = 0.009) but not from those of the red fin tetra (Mann-Whitney U-test, p = 0.17).

Discussion

Thus the experiment has shown that the schooling behavior of fish explorating a new area

Table. Duration of the fish stay in the stationary net trap.

Composition of experimental groups	No. of experiment	Number of fishes	Upper inflection point of logistic curve (duration of fish stay in the trap), min			Number of points used for calculation (N)
			Mean	Error	Standard deviation	
Red fin tetra	1	10	83.80	3.85	17.22	20
	2	10	75.40	7.40	33.09	20
	3	10	76.95	9.20	42.16	21
	4	10	74.10	13.95	57.52	17
	5	10	72.20	15.65	56.43	13
	Mean		76.49	1.99	4.44	5
Lemon tetra	1	10	>185			37
	2	10	>185			37
	3	10	>185			37
	4	10	>185			37
	5	10	>185			37
	Mean		—			
Mixed groups (red fin tetra + lemon tetra)	1	5+5	54.70	13.55	64.98	23
	2	5+5	73.90	6.35	31.11	24
	3	5+5	16.55	8.20	24.60	9
	4	5+5	15.95	10.20	28.85	8
	5	5+5	113.20	8.90	56.29	35
	Mean		54.86	18.37	41.07	5

depends on the composition of individuals in the school. When the school consists of individuals rapidly perceiving new information (1st experimental variant, schools of red fin tetra), the exploration of the trap inner space is soon completed, and the school comes out of it. When individuals rapidly perceiving information are absent from the school (2nd experimental variant, schools of lemon tetra), the exploration of the trap interior proceeds for a long time. In the case of considerable individual differences between the school members in the rate of perceiving new information (3rd experimental variant, mixed schools); the school behavior is determined by the reaction of individuals most actively perceiving new information.

It is possible that alteration in the school behavior in the course of experiment is connected with formation of a spatial map of the area in individuals which allows them to orient themselves inside the trap and to find the way out of it (Reese 1989).

In our experiments, the ratio between well- and poor-learning fishes was 1 : 1. At different ratios between active and passive portions of the school, the resulting reaction may depend on physical abilities of certain fishes, activity of initiating part of the group, and intensity of schooling interactions between individuals (Radakov 1972, Pavlov 1979, Gerasimov 1983).

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Взаимовлияние особей с разными способностями к обучению в исследовательском поведении тетрагоноптеруса (*Hemigrammus caudovittatus*, Characinidae).

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РЕЗЮМЕ. С целью выяснения вопроса о том, действуют ли особи стайных рыб с разными аналитическими способностями при ориентировочно-исследовательской активности независимо, или их поведение коррелировано, проведено сравнение двух линий тетрагоноптеруса (*Hemigrammus caudovittatus*), различающихся по способности к обучению. Использовали нормально окрашенную форму (тетра-плотвичка, ТП) с высокой обучаемостью и морфу с желтоватым оттенком тела (лимонная тетра, ЛТ) с низкой обучаемостью в трех вариантах экспериментальных групп: 10 ТП (I), 10 ЛТ (II), 5 ТП + 5 ЛТ (III). Группу помещали в большой аквариум с находящейся в нем моделью ставного невода и контролировали время от захода рыб в ловушку до выхода. I быстро находили выход из ловушки, II практически не выходили из нее. Скорость выхода стай III не отличалась от I. Таким образом, поведение стайных рыб при обследовании новой акватории зависит от состава особей в стае. При этом в случае значительных различий между членами поведение стаи определяется реакциями наиболее активно воспринимающих новую информацию особей, а не является средним арифметическим по всей группе.